Integrating planetary boundaries into the life cycle assessment framework for assessing absolute environmental sustainability of products and systems

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Integrating planetary boundaries into the life cycle assessment framework for assessing absolute environmental sustainability of products and systems

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Abstract

Life Cycle Assessment (LCA) is a widespread tool that quantifies environmental impacts from the life cycles of products and systems expressed into a number of impact categories (climate change, ozone depletion, nutrient enrichment, etc.). LCA addresses environmental sustainability in a relative sense: systems having the same functionality are compared with the purpose of identifying the one with the overall lowest environmental impact (i.e. highest eco-efficiency). To better compare across categories, impacts from systems under study may be related to society's background impact to bring about a perspective on the magnitude of the impacts compared to those already exerted. Such assessments provide however no information on the harmfulness of a given impact on the affected ecosystems. LCA thus suffers from not being able to assess environmental sustainability in an absolute sense.

We suggest integrating planetary boundaries (PB) into the LCA framework to address this shortcoming. PB have emerged as a popular concept that defines boundaries that, if exceeded, may trigger non-linear, abrupt environmental change within continental- to planetary-scale systems or undermine the resilience of the Earth system (e.g. for climate change, ocean acidification and global freshwater use). It has been proposed that an environmentally sustainable global society must stay within the safe operating space permitted by the PB. PB may thus fulfill the role of absolute sustainability reference points that LCA currently lacks.

Here, we demonstrate how PB can be linked to LCA impact categories via impact modeling. This allows for the expression of impacts into person equivalents of safe operating space. A person equivalent is, in this context, defined as the maximum amount of environmental impact that an average person can cause when society as a whole must stay within the safe operating space. This is valuable in a system design context when one faces trade-offs (and possibly synergies) between types of impacts. For instance one system configuration may have high greenhouse gas emissions, while another may have high land use and leaching of nutrients into water bodies. Expressing impacts relative to the safe operating space allows for identifying the system configuration with the overall lowest environmental harmfulness, understood as their aggregated contribution to the potential exceedance of safe operating space. The perspective of the person equivalent also serves to illustrate the current unsustainability of most western economies. For these economies we show quantitatively that obtaining a state of environmental sustainability either calls for a dramatic (and probably unrealistic) increase in the average eco-efficiency of products and systems or a decrease in average material wealth. This suggests the existence of a trade-off between satisfying the

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needs and wants of all people across space and time and keeping within the safe operating space.

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